THE MONOPOLIES COMMISSION

Report on the Supply of Chemical Fertilisers

Presented to Parliament in pursuance of Section 9 of the Monopolies and Restrictive Practices (Inquiry and Control) Act, 1948

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* Mr. Black, because of his past connections with the industry, has not taken part in th inquiry.

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PRINCIPAL ABBREVIATIONS USED IN THE REPORT

Companies, Associations, etc.

A.B.O.F.	Association of British Organic Fertilisers Ltd.
B.B.S.	British Basic Slag Ltd.
B.S.A.F.	British Sulphate of Ammonia Federation Ltd.
B.S.P.A.	Basic Slag Producers Association
C.A.C.	Central Agricultural Control of I.C.I.
C.B.S.	Corby Basic Slag Ltd.
C.W.S.	Co-operative Wholesale Society Ltd.
Fisons	Fisons Ltd.
F.M.A.	Fertiliser Manufacturers' Association Ltd.
I.C.I.	Imperial Chemical Industries Ltd.
I.D.A.C.	Import Duties Advisory Committee
I.S.C.	Imperial Smelting Corporation Ltd.
N.A.A.S.	National Agricultural Advisory Service (Ministry of Agriculture, Fisheries and Food)
N.A.C.A.M.	National Association of Corn and Agricultural Merchants Ltd.
N.C.C.	Nitrate Corporation of Chile Ltd.
N.F.U.	National Farmers' Union
P.R.A.	Phosphate Rock Agency Ltd.
S.A.I.	Scottish Agricultural Industries Ltd.
S.C.W.S.	Scottish Co-operative Wholesale Society Ltd.
S.M.A.	Superphosphate Manufacturers' Association Ltd.
S.N.F.U.	National Farmers' Union of Scotland
U.F.U.	Ulster Farmers' Union

Fertilisers

C.C.F.	Concentrated Complete Fertiliser
P.M.P.	Potassic Mineral Phosphate

Plant Nutrients

The chemical symbols for the elements are N (nitrogen), P (phosphorus), K (potassium). The Fertilisers and Feeding Stuffs Regulations require the nutrient content of fertilisers to be shown in terms of N, P_2O_5 (phosphoric acid) and K_2O (potash). In abbreviated descriptions of nutrient content or ratios the symbols N P K are commonly used instead.

REPORT ON THE SUPPLY OF CHEMICAL FERTILISERS

Introduction

(i) The following report on the supply of chemical fertilisers in the United Kingdom is submitted in compliance with Section 2 (1) of the Monopolies and Restrictive Practices (Inquiry and Control) Act, 1948. The reference was received from the Board of Trade on 29th October, 1955. On 30th August, 1956, the Board made a direction under sub-sections (3) and (4) of Section 29 of the Restrictive Trade Practices Act, 1956, that the reference, which would otherwise have lapsed under the provisions of that Act, should be proceeded with as if it had been made after the commencement of the Act. Section 29 (1) of the 1956 Act restricts the scope of our findings in relation to references under Section 2 (1) of the 1948 Act, and this is the first report we have made which is affected by this restriction. The reference and direction are reproduced in Appendix 1.

(ii) We have received evidence from the principal suppliers of the six classes of chemical fertilisers with which our reference is concerned. These are:

Imperial Chemical Industries Ltd. (I.C.I.), the principal supplier of nitrogenous fertilisers in class (*a*);

Potash Ltd., the principal supplier of potassic fertilisers in class (*b*);

Fisons Ltd. (Fisons), the principal supplier of superphosphate in class (*c*) and compounds in class (*f*), one of the principal suppliers of ground rock phosphate in class (*d*) and basic slag in class (*e*), and the principal purchaser of fertilisers in class (*b*);

British Basic Slag Ltd. (B.B.S.), another principal supplier of fertilisers in class (*e*).

(iii) We have also received evidence from other suppliers of chemical fertilisers and their trade associations, from a number of farmers and their associations, from Universities and colleges, and from the Government Departments concerned. From some of these we took oral evidence after we had considered their written submissions. A list of our principal sources of evidence is given in Appendix 2. Members of the Commission and staff visited certain factories and agricultural research stations.

(iv) In October and November, 1957, representatives of B.B.S., Potash Ltd. and Fisons attended separate meetings to clarify outstanding matters of fact, and in March, 1958, representatives of I.C.I. attended a similar meeting; representatives of I.C.I.'s subsidiary company, Scottish Agricultural Industries Ltd. (S.A.I.) and of the British Sulphate of Ammonia Federation Ltd. (B.S.A.F.), a trade association with which I.C.I. is closely concerned, also attended and gave evidence during the course of the latter meeting.

(v) In April, 1958, we informed each of the four principal suppliers named in paragraph (ii) above of our provisional conclusion that the conditions of

the 1948 Act, as amended by the 1956 Act, prevailed in respect of each of the six classes of chemical fertilisers.* Each of them made certain representations to us in writing and, in July, 1958, representatives of Fisons and I.C.I. attended separate hearings for the purpose of discussing with us whether the " conditions " or any of the " things done " operated or might be expected to operate against the public interest; in October, 1958, representatives of Potash Ltd. attended a similar hearing. At these three hearings the parties concerned were represented by Counsel. Representatives of B.S.A.F. again attended during part of the hearing with I.C.I. We offered B.B.S. the opportunity to attend a similar hearing; the company did not wish to avail itself of this and we ourselves did not think any further discussion necessary.

(vi) We wish to record our appreciation of the assistance given us by I.C.I., Fisons, Potash Ltd. and B.B.S. and all the others who have provided us with the information required in our investigation. Some of the information relates to confidential business affairs and we have been careful not to disclose it in our report unless it is essential for a proper understanding of the issues.

* We subsequently concluded that the conditions did not prevail in respect of class (*d*) (see paragraph 364).

PART I. GENERAL

CHAPTER 1. GENERAL SURVEY

(1) Description of the Goods

1. Fertilisers, whether of natural or chemical origin, are applied to the soil to ensure that plant crops shall have adequate supplies of the nutrient elements necessary for healthy growth. The major elements, i.e. those required in quantity and in which soils are frequently deficient, are nitrogen, potassium, phosphorus and calcium, and it is in order to provide one or more of these elements that chemical fertilisers are principally prepared and used. Other elements essential for plant growth are magnesium and the "trace" elements, of which manganese and boron are the most important, while sodium, though not an essential nutrient, is particularly beneficial to some crops. Most soils contain a sufficient quantity of these elements but deficiencies may develop and require supplementation.

2. The goods described in the reference (see Appendix 1) comprise the great bulk of the chemical fertilisers now used in the United Kingdom for the provision of nitrogen, potassium and phosphorus. Some of these goods also contain calcium, but the principal calcium fertiliser, namely lime, is not included. The goods, as set out in sub-paragraphs (*a*) to (*f*) of paragraph 1 of the reference, (hereinafter referred to as classes), fall into nutrient groups as follows:

	Nutrient supplied
Class (a) Ammonium sulphate, Nitro-Chalk, sodium nitrate, ammonium nitrate	Nitrogen (N)
Class (b) Potassium chloride, kainite, potassium sulphate	Potassium (K)
Class (c) Calcium superphosphate (single), calcium superphosphate (triple)	Phosphorus (P)
Class (d) Ground rock phosphate	Phosphorus (P)
Class (e) Basic slag	Phosphorus (P)
Class (f) Compound and complex fertilisers	Two or more of the elements N, P and K.

As defined in the reference, fertilisers in class (*f*) must contain two or more of the nutrient elements N, P and K of which at least one must be present in inorganic or synthetic form. "Complex" fertilisers are those in which two or more nutrient elements are present in chemical combination, e.g. fertilisers containing ammonium phosphate or the naturally occurring potassium nitrate. "Compound" in the narrower sense is used, contrary to ordinary chemical usage, to describe mixtures of substances none of which individually contains more than one nutrient element, e.g. mixtures of ammonium sulphate, potash and calcium superphosphate, or of bonemeal and potash. The distinction between complex and compound is not commonly made in the fertiliser trade, and generally throughout the report we use the term compound as covering both.

3. The fertilisers in classes (*a*) to (*e*), when applied direct to the soil, are commonly described as " straight " fertilisers, in contradistinction to those in class (*f*). The distinction is particularly important in the case of ammonium sulphate, potassium chloride and the superphosphates, of which greater quantities are used in compounds than as " straights ". This practice is recognised in the terms of the reference, " supply " in the case of classes (*a*), (*b*) and (*c*) being qualified by the words " as fertilisers or for use in the production of fertilisers ".

(2) Use and Application

4. In broad terms, *nitrogen* is essential for healthy luxuriant growth and there are very few soils so rich in available nitrogen that additional quantities are not required for the maximum production of almost any crop other than leguminous crops, which can " fix " atmospheric nitrogen. The high solubility of nitrates (the form in which nitrogen is principally taken up by the plant) frequently leads to nitrogen starvation. Their marked effect on leaf development makes nitrogen fertilisers particularly valuable for crops grown mainly for their leaves such as kale, maize and grass. *Potash* is essential for healthy growth. It assists the storage of starch and sugar and its chief use is for crops which lay up large quantities of carbohydrates, such as potatoes, sugar beet, tomatoes and glasshouse crops. Cereals grown on light and chalky soils may also benefit from potash. *Phosphorus* assists early growth, hastens maturity and improves root and seed development. Among chemical fertilisers phosphatic fertilisers are used in greater quantity than any others, but the use of nitrogen and potash has increased more rapidly in recent years. Generally, it is important to maintain a balance between the amounts of the various nutrients added to the soil, whether of chemical or organic origin. Nitrogen and potash, for example, may be more successful in combination than when used singly.

5. As might be expected fertiliser requirements, as indicated by the results of innumerable experiments, differ with crops, types of soil and climate. The timing of application, e.g. whether before sowing, at the time of sowing or subsequently as a top dressing, is also important, while in some cases a crop may do better with two separate applications. If more than one nutrient is required this may be secured by successive applications of straight fertilisers, by mixing these fertilisers on the farm before application, or by the use of a compound fertiliser with or without a supplementary application of a straight fertiliser. Methods of application of chemical fertilisers may be divided into broadcasting, whether by hand or mechanical means, and drilling.* The latter method secures a concentration of the fertiliser close to the seed and for some purposes is more effective and economical. Until recently broadcasting was the method principally employed on British farms, and we are told that it is likely to remain the method for applying fertilisers to grassland and for top dressing growing arable crops. The common type of combine drill, which sows seed and fertiliser together, was introduced into this country during the war and is now widely used ; it is satisfactory and economical for normal needs when

* Excluding liquid application which, with the exception of certain horticultural fertilisers in class (*f*), does not apply to the fertilisers in this reference.

drilling cereal crops. Field experiments carried out at Rothamsted and elsewhere have indicated that with many crops drilling with a given quantity of fertiliser gives the same result as broadcasting twice that amount. The seeds of some crops are adversely affected by the contiguity of a fertiliser particularly if it is of high concentration; this is avoided by the use of the " placement " drill, which places seed and fertiliser simultaneously but at a fixed distance apart. These drills are now being developed in the United Kingdom. For use in a combine or placement drill fertilisers must be granulated and of regular size or in free-flowing crystalline form. For broadcasting they may be in powder or other form, but granulated fertilisers have the advantage of not blowing away in windy weather. During recent years simple spinning disc distributors, which rely on centrifugal action to distribute the fertiliser, have become popular; for use with these machines, also, the fertiliser should be in granules of a uniform size.

(3) Particular Qualities of Chemical Fertilisers*

Class (a): Nitrogenous Fertilisers

Ammonium sulphate

6. Ammonium sulphate (commonly described as sulphate of ammonia) is sold as a white or greyish crystalline powder containing 21 per cent. of nitrogen and less than ·25 per cent. free sulphuric acid. In normal soils the ammonia is converted fairly rapidly to nitrates, in which form nitrogen is chiefly taken up by the plant. Ammonium sulphate is principally used in the spring; it is usually applied to seed-beds shortly before sowing and also as early top dressings to corn and roots. It is extensively used for cereals, potatoes, grass, kale and fodder roots, but there are few crops, apart from leguminous ones, on which it cannot be used with advantage. On soils short of lime the repeated use of ammonium sulphate can lead to harmful acid conditions which, however, can be remedied by liming. Ammonium sulphate is the most important of the quick-acting nitrogenous fertilisers used in this country. It is the principal nitrogenous constituent in compound fertilisers and is well suited for incorporation in farm mixtures.

Sodium nitrate

7. Sodium nitrate (commonly described as nitrate of soda) is a crystalline solid containing 16 per cent. nitrogen and is very soluble in water. As all the nitrogen is present in the form of nitrate it is taken up immediately by the crop and it is therefore slightly more rapid in its action than ammonium sulphate. It is almost always used as a top dressing and, on account of its sodium content, is particularly valuable for sugar beet. Sodium nitrate is one of the oldest nitrogenous fertilisers, but its consumption in this country has declined in recent years largely on account of its relatively high cost, and its use is now practically confined to sugar beet and related crops.

Ammonium nitrate

8. Ammonium nitrate is not used as a straight fertiliser in this country, its hygroscopic nature making it sticky and unusable without further treat-

* The description of the various fertilisers in this section has been based principally on that in " Manures and Fertilizers " by H. V. Garner, M.A., B.Sc. (Ministry of Agriculture, Fisheries and Food: Bulletin No. 36: H.M.S.O., 1957).

ment. It is one of the constituents of Nitro-Chalk and of certain concentrated compounds which have just been put on the market.

*Nitro-Chalk**

9. Nitro-Chalk is a granular mixture of ammonium nitrate and calcium carbonate and is made in two qualities containing respectively 15·5 and 21 per cent. nitrogen. Half of this nitrogen is in the form of nitrate and is hence immediately available to the plant; the other half is in the form of ammonia and becomes available slightly later. The calcium carbonate content makes Nitro-Chalk particularly suitable for slightly acid soils and its granular form makes it easy to handle and useful as a top dressing for many crops, particularly cereals and grassland.

Class (b): Potassic Fertilisers

Potassium chloride

10. Potassium chloride is marketed in two principal qualities: high grade muriate of potash, containing 60 per cent. K_2O and only about 3 per cent. of common salt (i.e. 97 per cent. pure potassium chloride) and muriate of potash containing 50 per cent. K_2O and about 15 per cent. common salt. High grade muriate is available both in a powder form, used for compounds, and as free-flowing flotation potash which is suitable for use as a straight fertiliser. High grade muriate is suitable for potatoes, beans, clover, lucerne, flowers and some fruits, and for the combine drilling of cereals on soils which are particularly deficient in potash. The 50 per cent. muriate can be used for similar purposes and is particularly suitable in mixtures for such crops as grass, mangolds and sugar beet where the salt content is an advantage. The great bulk of the chemical potash used by the farmer is applied in the form of compounds, of which the high grade muriate is the principal potash constituent.

Kainite

11. Kainite is a low grade muriate containing 16 to 20 per cent. K_2O and about half its weight of common salt. Kainite from some sources also contains magnesium salts. It is used for mangolds and sugar beet, sometimes in part replacement of agricultural salt.

Potassium sulphate

12. Potassium sulphate (commonly known as sulphate of potash) contains 48 per cent. K_2O and practically no chloride or common salt. It is preferred for those crops which tend to be sensitive to the chloride found in the other forms of potash, the principal ones being glasshouse tomatoes and lettuce, soft fruits and, to a less extent, potatoes. Potassium sulphate is also used in making some compounds.

Class (c): Calcium Superphosphate (Single and Triple)

13. The principal fertiliser ingredient of both single and triple superphosphate is the water soluble monocalcium phosphate, the triple product containing a larger proportion than the single. Other calcium phosphates in insoluble form, calcium sulphate (in the single product), certain trace

* "NITRO-CHALK" is a registered trade mark. A similar mixture containing 20·5 per cent. nitrogen is marketed under the trade mark of "NITRA-SHELL", but is not covered by our terms of reference.

elements and other constituents of the rock from which superphosphate is manufactured are also present.

Single superphosphate

14. Single superphosphate is made both in granular and powder form, and contains usually 18 per cent. water soluble P_2O_5. It is the most active of the phosphatic fertilisers, being particularly suitable for arable crops. It is most profitably used on potatoes and roots. It gives cereal crops a good start and hastens ripening and for these it is more effective when drilled. It is also valuable in establishing grass seed. Superphosphate, though providing water soluble phosphate, is not washed out of the soil but passes gradually into relatively insoluble form. On acid soils it reaches a state in which it becomes relatively useless, a result which can be avoided to some extent by liming and by the use of combine drilling. Generally, the need for superphosphate depends on the state of the soil and also on rainfall, the need being reduced in drier areas. Superphosphate is particularly suitable for inclusion in compounds and more than half of the superphosphate consumed in the United Kingdom is used in this form.

Triple superphosphate

15. Triple superphosphate is made both in granular and powder form and contains about 47 per cent. P_2O_5. It is used for the same purposes as single superphosphate but, as it is more concentrated, in smaller quantities. It is an important constituent of a range of concentrated compounds.

Class (d) : Ground Rock Phosphate

16. Ground rock phosphate is a fine powder containing usually about 27 per cent. P_2O_5 in the form of insoluble tricalcium phosphate together with some trace elements and other materials. It gives best results (i) on acid soils deficient in phosphorus, (ii) in regions of adequate rainfall and (iii) on crops with a long period of growth such as swedes, turnips and grass. Its use on grassland under favourable conditions gives results comparable with those of basic slag. It is used as a constituent of one or two compounds. Generally, the use of ground rock phosphate as a fertiliser is declining in this country.

Class (e) : Basic Slag

17. Basic slag is supplied for fertiliser use as a finely ground powder. It contains phosphoric acid in various combinations, lime and other valuable elements. In the grades commonly supplied in this country the total P_2O_5 content varies from about 8 to 22 per cent. and the amount which is soluble in citric acid from about 6 to 16 per cent. High soluble slags are more active than low soluble ones, the citric soluble P_2O_5 being readily utilised by crops under most climatic and soil conditions. Basic slag is particularly valuable for grassland, the pastures of this country offering a large and steady outlet for it. It has also an important place in arable cultivation, and is used for turnips and swedes on soils deficient in phosphate and lime and as a seed-bed application for autumn and spring-sown corn crops.

Class (f) : Compound Fertilisers

18. These fertilisers, by definition, contain two or all three of the plant nutrients nitrogen, potash and phosphorus and fall into two groups: those

made only from inorganic constituents—which are the most important—and those made from both inorganic and organic materials. A further distinction is commonly made in the first group between concentrated compounds and others. The most concentrated compounds now contain 40 or more per cent. of nutrients. Very few manufacturers have so far marketed compounds of this degree of concentration, and it is customary for manufacturers to describe all compounds containing 30 or more per cent. of plant nutrients as "concentrated" or "high analysis compounds". Compounds with a lower content, usually based on single superphosphate, are sometimes described as "single strength".

19. Inorganic compound fertilisers have a wide application in agriculture in this country; in 1956–57 60 per cent. of the nitrogen, 64 per cent. of the phosphorus and about 85 per cent. of the potash in the chemical fertilisers consumed was applied in compounds. They are made in a variety of nutrient combinations adapted for various crops and soil conditions and the great bulk of them, including all the concentrated or high analysis compounds, are made in granular form and can accordingly be used for combine or placement drilling, a practice which, as in the case of certain straight fertilisers, is beneficial to the crop and enables smaller quantities to be used.

20. The organic-inorganic compounds are of little importance in large-scale farming and are mainly used by market growers and horticulturists. For these uses they combine some of the advantages of chemical and natural fertilisers.

(4) The Principal Suppliers of Fertilisers

21. Apart from the straight potassic fertilisers, all of which are imported, the greater part of the chemical fertilisers used in the United Kingdom is manufactured here, though in part from imported materials. The leading suppliers in each class are:

Class (*a*) Imperial Chemical Industries Ltd. (I.C.I.);

Class (*b*) Potash Ltd.;

Classes (*c*) and (*f*) Fisons Ltd. (Fisons);

Class (*d*) Fisons and Scottish Agricultural Industries Ltd. (S.A.I.);

Class (*e*) Fisons and British Basic Slag Ltd. (B.B.S.).

In the table below we show, class by class, the total sales in the United Kingdom in the fertiliser year* 1957–58 and the sales of the most important suppliers in each class:

Class (a)	*Supplier*	*Tons*	£(1)
Ammonium sulphate	I.C.I. (Manufacturer)	474,718	9,350,709
	Other Manufacturers	308,504	6,031,549
Nitro-Chalk	I.C.I. (Sole Manufacturer)	440,139	7,857,200
Sodium nitrate	Nitrate Corporation of Chile Ltd. (Importer)	8,308	220,467
Ammonium nitrate	Nil	Nil	Nil
	Total	1,231,669	23,459,925

(1) The figures of value are, in some cases, estimations.

* The fertiliser year which runs from 1st July to 30th June is the one used by Agricultural Departments for subsidy purposes. Except where otherwise indicated the years referred to in this report are on this basis.

Class (b)				
Potassium chloride ... Potassium sulphate ... Kainite	Potash Ltd. (Importer)	458,558	7,483,181
	Other Importers(1)	141,142	1,899,726
	Total	599,700	9,382,907
Class (c)				
Single superphosphate ...	Fisons (Manufacturer)	95,315	1,367,077
	Other Manufacturers	159,846	2,244,854
Triple superphosphate ...	Fisons (Manufacturer)	25,897	929,618
	Other Manufacturers	960	33,231
	Total	282,018	4,574,780
Class (d)(2)				
Ground rock phosphate ...	S.A.I. (Manufacturer)	10,183	106,922
	Fisons (Manufacturer)	9,229	106,905
	Other Manufacturers	16,690	196,027
	Total	36,102	409,854
Class (e)				
Basic slag	Fisons (Distributor)	304,863	2,193,307
	B.B.S. (Distributor)	283,564	1,771,552
	Others...	170,632	1,320,497
	Total	759,059	5,285,356
Class (f)				
Compound fertilisers ...	Fisons (Manufacturer)	1,017,853	25,050,466
	Other Manufacturers	1,348,907	32,663,994
	Total	2,366,760	57,714,460

(1) The figures for other importers of potash include sales from Board of Trade stocks which had been imported in earlier years.
(2) The figures for ground rock phosphate include sales for straight use (which are within our terms of reference) and sales for compounding (which are not)—see paragraph 364.

22. I.C.I.'s output of ammonium sulphate is sold, along with that from most of the other producers, through the agency of the British Sulphate of Ammonia Federation Ltd. (B.S.A.F.) for which I.C.I. acts as sub-agent. I.C.I. and Fisons both have production interests in classes in which they are not the leading suppliers; I.C.I. manufactures compound fertilisers of high concentration and its subsidiary, S.A.I., manufactures fertilisers in classes (*c*), (*d*), (*e*) and (*f*). Fisons' subsidiary, Nitrogen Fertilisers Ltd., manufactures ammonium sulphate and Fisons has just installed plant for the manufacture of ammonium nitrate to be used in its concentrated compounds.

(5) The Consumers of Fertilisers : Farmers

23. Since our reference includes, in classes (*a*), (*b*) and (*c*), materials which may be used either as straight fertilisers or as ingredients in the production of compounds, the consumers with whom we are concerned include the manufacturers of compounds in class (*f*). The other principal class of consumers, who ultimately consume the bulk of all the fertilisers in our reference, are the farmers. In 1958 there were over 500,000 agricultural

holdings in the United Kingdom. A large number of these were part-time or spare-time holdings and it is estimated that there were not many more than 300,000 full-time farmers. There is considerable variation in the size and type of farm. The distribution of holdings among size groups in June, 1957, can be summarised as follows :—*

Size in acres	1–4¾	5–14¾	15–49¾	50–99¾	100–149¾	150–299¾	300 and above	Total holdings
England and Wales	76,984	68,122	80,871	58,862	30,497	33,129	13,271	361,736
Scotland ...	16,308	17,092	13,173	9,686	5,655	6,525	2,310	70,749
Northern Ireland	6,476	17,231	34,158	11,747	2,537	1,249	386	73,784
Totals ...	99,768	102,445	128,202	80,295	38,689	40,903	15,967	506,269

24. The principal farmers' associations are the National Farmers' Union (N.F.U.), the National Farmers' Union of Scotland (S.N.F.U.) and the Ulster Farmers' Union (U.F.U.). Each of the Unions has a central Council and an extensive local organisation, and includes in its membership the great majority of the full-time professional farmers of its country. Among other activities the Unions represent the farming community in negotiations with the Government.

25. Another organisation, the Farmers and Smallholders Association, was formed in 1951 and has a small membership drawn from England, Wales and Scotland. Its original object was to "help all those who are being dispossessed of their freeholds or tenancies" under the Agriculture Act, 1947. It is now interested in farm costs (see paragraphs 377 to 381).

(6) Legislation and Government Policy

The Board of Trade

26. The chemical fertiliser industry falls within the Board of Trade's general responsibility for trade and commerce and its particular responsibility for the production of chemicals. The Board keeps in touch with the industry to ensure that adequate supplies of fertilisers are available for home consumption and that export trade is maintained and developed as far as possible. Discussions are held from time to time with individual traders and trade associations. The only statutory controls now exercised by the Board directly affecting the supply of fertilisers are those on imports and tariffs.† (Certain requirements in the Fertilisers and Feeding Stuffs Act, 1926, which relate to the sale of chemical fertilisers and which are not the Board of Trade's responsibility are dealt with in paragraph 29 below.)

Import arrangements and tariffs

27. The importation of ammonium sulphate, ammonium nitrate, natural sodium nitrate, potassium sulphate, single and triple superphosphate,

* From figures supplied by the Ministry of Agriculture, Fisheries and Food and the Ministry of Agriculture for Northern Ireland. The figures for England, Wales and Scotland exclude rough grazings. The figures for Northern Ireland relate to the total superficial area. The groupings for Scotland are " 1–5 " acres, " 5¼–15 ", " 15¼—50 ", etc., and for Northern Ireland " 1–5 " acres, " 6–15 ", " 16–50 ", etc.

† Until 1st December, 1958, the export of nitrogenous fertilisers was subject to licensing control.

phosphate rock (raw or ground) and basic slag is now allowed under Open General Licence from all sources. Kainite, potassium chloride, ammonium nitrate/calcium carbonate mixtures and compound fertilisers may be imported under the Open General Licence from all sources other than the Eastern area for which a specific licence is required. Specific licences to import most of these fertilisers from East Germany and Russia, the principal sources in the Eastern area, are freely granted. Ammonium sulphate, ammonium nitrate/calcium carbonate mixtures and compound fertilisers are subject to an import duty of £4 a ton; ammonium nitrate to a duty of 20 per cent. ad valorem; single and triple superphosphate to a duty of 17½ per cent. ad valorem and basic slag to a duty of 10 per cent. ad valorem. Natural sodium nitrate, potassium chloride, potassium sulphate, kainite and phosphate rock (raw or ground) are free of duty.

The Agricultural Departments

28. The Ministry of Agriculture, Fisheries and Food, the Department of Agriculture for Scotland and the Ministry of Agriculture of Northern Ireland are concerned to encourage a greater and more informed use of fertilisers. They do so primarily through advisory services and the payment of contributions to farmers to offset part of the cost of their purchases of chemical fertilisers, viz. the fertiliser subsidies. The Departments are also responsible for the administration of the Fertilisers and Feeding Stuffs Act, 1926.

Fertilisers and Feeding Stuffs Act, 1926

29. The Act came into force in 1928 and superseded earlier enactments of 1893 and 1906. Its main concept is that farmers should be supplied with particulars of the composition of the fertilisers and feeding stuffs sold to them so that they can assess the quality and appropriateness of the goods and use them to the best advantage. The seller's statement has effect as a warranty within the prescribed limits of error. The Act with the current Schedules and Regulations made under it requires a seller of any of the principal fertilisers to state in writing the amounts of nitrogen (N), phosphoric acid (P_2O_5),* and potash (K_2O) contained therein expressed as a percentage by weight of the product. For ammonium sulphate the amount of free sulphuric acid must also be shown and for basic slag and ground rock phosphate the degree of fineness. Limits of variation are prescribed. The same particulars must also be marked, or indicated by a mark, on the containers in which the fertiliser is supplied. The duty of enforcing the Act is laid upon local authorities who are required to appoint inspectors, official samplers and analysts. The Agricultural Departments are responsible for making Regulations under the Act and generally for ensuring that it is effectively administered. They obtain statistics of samples and other information from local authorities. In Northern Ireland inspectors are appointed by the Ministry of Agriculture.

Agricultural Advisory Services

30. In England and Wales the National Agricultural Advisory Service (N.A.A.S.) was set up in 1946 by the Ministry of Agriculture and Fisheries

* P_2O_5 content must be shown as follows: for superphosphate the water soluble content, for compounds the water soluble and insoluble content, for ground rock phosphate the total content and for basic slag the citric soluble and total content.

to give technical and practical advice to farmers. The services available to farmers include direct advice on the use of fertilisers under individual conditions, field demonstrations and experiments and the spreading of information generally by holding meetings and issuing pamphlets. In Scotland a similar advisory service is given by advisory officers at the three Agricultural Colleges and in Northern Ireland by officers at the Queen's University of Belfast. The Agricultural Departments consider that these services have played an important part in securing an increased use of fertilisers in recent years.

Subsidies

31. The fertiliser subsidies are the most important of the Government measures affecting the use of fertilisers. These have been paid to farmers in England, Wales and Scotland on phosphatic fertilisers since 1st July, 1951, and on nitrogenous fertilisers since 1st July, 1952, and on both in Northern Ireland since 1st July, 1956.* They apply to chemical fertilisers containing nitrogen and/or phosphoric acid except those compound fertilisers in which these ingredients are wholly derived from organic material. No subsidy is paid in respect of potash,† whether in straight or compound fertilisers.

32. The fertiliser subsidy is included in the production grants through which, together with guaranteed prices for the main farm products,‡ the Government discharge their obligation to promote and maintain, in the words of Section 1 of the Agriculture Act, 1947, " . . . a stable and efficient agricultural industry capable of producing such part of the nation's food and other agricultural produce as in the national interest it is desirable to produce in the United Kingdom, and of producing it at minimum prices consistently with proper remuneration and living conditions for farmers and workers in agriculture and an adequate return on capital invested in the industry". The amount of the fertiliser subsidy is determined by the Government, together with the amounts of the other grants and any changes in guaranteed prices, in the light of their conclusions from the Annual Review of the economic condition and prospects of the agricultural industry which is held in February–March of each year under the provisions of the Agriculture Acts, 1947 and 1957. In determining the amounts to be contributed respectively to nitrogenous and phosphatic fertilisers the Government take account of particular needs of the industry, the requirements of good husbandry, the relationship between fertiliser prices and the limit of Exchequer assistance (see next paragraph) and any other relevant factors.

33. Powers to make subsidy payments to agricultural users of fertilisers in accordance with the annual schemes to be made by the appropriate

* Until 1956 fertiliser subsidies in Northern Ireland were paid to the manufacturers as were subsidies in the rest of the United Kingdom from 1939 to 1950–51 (see paragraphs 67 to 75).

† Except in Northern Ireland where, under successive Agricultural Development (Fertiliser) Schemes, applicable only to farmers occupying not more than 50 acres of arable land, subsidies on potash have been paid since 1954. The contribution under the 1958 Scheme was at the rate of 1s. 0d. per unit of K_2O.

‡ The Agriculture Act, 1957, empowers the Government to provide guaranteed prices for fat cattle, fat sheep, fat pigs, milk, hen and duck eggs, wool, wheat, barley, oats, rye and potatoes; the Sugar Act, 1956, makes similar provision in respect of sugar beet.

Ministers are provided in the Agriculture (Fertilisers) Act, 1952.* The provisions of the Act as amplified in the current scheme define the persons who are eligible for the subsidy as "occupiers of agricultural land" and the latter as "land used as arable, meadow or pasture ground or for the purpose of poultry farming, market gardens, nursery grounds, orchards or allotments including allotment gardens within the meaning of the Allotments Act, 1922 or the Allotments (Scotland) Act, 1922". Associations of farmers, allotment holders and other similar associations acquiring fertilisers in bulk for distribution to members are also eligible. The Act requires that schemes must be devised so that, so far as is practicable, no occupier shall receive more than one half of his expenditure on a subsidised fertiliser. The current scheme, like its predecessors, provides that no contribution "shall exceed one half of the cost of the fertiliser when delivered to the premises of the purchaser (excluding any charge for credit or spreading and less any rebate or discount)". Payments are made on the basis of application forms showing the amounts and kinds of fertilisers bought, the dates of delivery and the cost to the occupier, signed by the latter and countersigned by his supplier. Applications cannot be made for less than 4 cwt. of fertiliser. By agreement between the parties the subsidy can be paid to the supplier (merchant or manufacturer) instead of to the farmer.

34. The kinds of fertilisers on which subsidies are paid and the contributions payable are prescribed in the annual statutory schemes. Contributions are at standard rates—for specified straight fertilisers of a standard nutrient content a fixed sum per ton, for other fertilisers a fixed sum per unit content of nitrogen or phosphoric acid per ton. The rate per nutrient is now the same in straight and compound fertilisers except in the case of ground rock phosphate and basic slag. The 1958–59 rates for each 1 per cent. of nutrient per ton are as follows: N 9s. 6d.; soluble P_2O_5 7s. 6d.; insoluble P_2O_5 4s. 6d. in compounds, 4s. in ground rock phosphate. Contributions are prescribed for a number of grades of basic slag but the relationship of contribution to P_2O_5 content is not uniform throughout the range. The contributions in Northern Ireland for basic slag are not the same as those in the rest of the United Kingdom. The subsidies for the principal fertilisers paid since 1951 are set out in Appendix 3. As will be seen the total amounts paid on deliveries made in the fertiliser years (July–June) 1956–57 and 1957–58 amounted to £21·2 million and £26 million respectively.

(7) The Processes of Manufacture of Chemical Fertilisers

Class (a): Nitrogenous Fertilisers

Ammonium sulphate

35. Ammonium sulphate is produced commercially by two processes, each of which has some variations. In the synthetic process the first stage is the manufacture of ammonia which is produced by combining, under conditions of high temperature and pressure and in the presence of a catalyst, nitrogen obtained from the air and hydrogen. In the method used

* There are a number of other enactments of a special nature under which certain farmers can obtain contributions to expenditure on fertilisers.

by I.C.I. these gases are produced by passing steam and air alternately over red hot coke. Two streams emerge, one containing a quantity of hydrogen and the other of nitrogen, each with a considerable admixture of other gases. By successive purifications the concentration of the required nitrogen and hydrogen is increased until they are mixed in the right proportion for ammonia (NH_3) synthesis.* The ammonia so produced is used by I.C.I. to make a variety of products, as also are the various gases obtained during its manufacture. In the next stage in the production of ammonium sulphate by I.C.I. one of these gases, carbon dioxide, is passed into a solution of ammonia in water (usually called ammonia liquor), and an ammonium carbonate solution is formed. This is reacted with finely ground calcium sulphate (anhydrite), some of which is obtained from a mine directly below one of I.C.I.'s works. Ammonium sulphate and calcium carbonate (chalk) are formed: the latter is filtered off and the solution evaporated to produce crystals of controlled size and shape.

36. In the process used by Nitrogen Fertilisers Ltd. the bulk of the nitrogen required for ammonia synthesis is obtained from the atmosphere by refrigeration and fractional distillation in an air separation plant. The hydrogen and the remainder of the nitrogen are obtained from coke oven gas supplied by pipe-line from John Lysaght's Scunthorpe Works Ltd., the other constituents being first removed by chemical purification and progressive refrigeration in a gas separation plant. Ammonium sulphate is manufactured by leading ammonia gas and concentrated sulphuric acid into saturators. Crystals form and are removed, washed and dried. Sulphuric acid is manufactured at the same works by the contact process from filter cake and, to a smaller extent, spent oxide.

37. In the other process used in the United Kingdom, ammonia arises as a by-product of the carbonisation of coal in gas retorts or coke ovens. The resultant coal gas contains ammonia, which must be removed before the gas can be used for industrial or domestic purposes. This is done in one of three ways. In the Direct Process, operated by two plants only, hot gas at a temperature of about 90°C. is passed into a vessel, known as a saturator, containing sulphuric acid. In the Semi-Direct Process, used by about half of the remaining plants, the gas is first cooled. The liquor which condenses passes to a distillation column or still, where the ammonia is stripped from it by means of steam and the still vapours fed back into the main gas stream: the whole of the gas is then passed through the saturator. In the Indirect Process the gas is passed through a condenser and then through a series of scrubbing towers where water absorbs the ammonia in the gas. The condenser and scrubber liquors are then mixed and passed on to a distillation column: the still vapours are fed to the saturator. The ammonia removed by any of these three processes reacts in the saturator with the sulphuric acid, forming ammonium sulphate solution, the concentration of which increases with the constant addition of acid and ammonia gas until solid ammonium sulphate is thrown out of the solution. This is removed from the saturator and fed to a centrifuge where the excess liquor is removed. Finally, the ammonium sulphate is washed and dried.

* Additional hydrogen, made from hydrocarbon gases obtained from another of I.C.I.'s works, may be added as available.

Nitro-Chalk

38. Nitro-Chalk, a granular mixture of ammonium nitrate and chalk or limestone, containing 15·5 per cent. or 21·0 per cent. nitrogen, is manufactured only by I.C.I. Ammonia gas is first oxidised in the presence of a catalyst to form oxides of nitrogen which are dissolved in water to produce a nitric acid solution. This is then neutralised with ammonia gas to give a hot solution of ammonium nitrate. The solution is then mixed with powdered chalk, produced during the manufacture of ammonium sulphate, or limestone to make a slurry. The slurry is treated so that it is formed into granules which are then screened to a given size.

Sodium nitrate

39. Sodium nitrate is obtained in Chile from the mineral "caliche". The caliche is mined and crushed, and the sodium nitrate extracted by a process of leaching.

Class (b) : Potash

40. *Potassium chloride* is obtained in a crude state by deep mining in France, Germany, Spain and other countries. The raw minerals—Sylvinite and, to a lesser extent, Carnallite and Hartsaltz—are crushed and ground and the potash salts purified to produce the high grade fertilisers either by solution and re-crystallisation or by the flotation process. *Potassium sulphate* is made from chloride by treatment with sulphuric acid or by reaction with Kieserite (magnesium sulphate). These processes are all carried out in the producing countries.*

Class (c) : Single and Triple Superphosphate

Single superphosphate

41. Single superphosphate is manufactured from phosphate rock and sulphuric acid. The rock is first ground in a mill to a suitable fineness and then mixed with the acid. The principal reaction is the conversion of the bulk of the insoluble tricalcium phosphate in the rock to a mixture of monocalcium phosphate and calcium sulphate. Various types of plant are in use. In one commonly used, the Broadfield, the raw materials are mixed and the resultant mass is then transferred to a "den" with a moving floor along which it slowly travels, gradually solidifying while the main part of the reaction is in progress. The mass is cut by revolving knives from the exit end of the den and transferred to store, where the reaction is completed. Granulation, if required, is effected by mixing the powdered superphosphate with water or steam and drying. In the steam process, which is the more recent, the powdered fertiliser is fed, together with steam, into a rotating drum, the "conditioner", inclined slightly on its axis. The granules are collected from the lower end, dried, cooled and screened for size.

Triple superphosphate

42. Triple superphosphate is manufactured by treating ground phosphate rock with phosphoric acid. The principal reaction is the conversion of the

* Small quantities of potassium sulphate have occasionally been made in the United Kingdom from imported potassium chloride.

bulk of the insoluble tricalcium phosphate in the rock to monocalcium phosphate, a higher yield of the latter being obtained than in the manufacture of single superphosphate. In the process used by Fisons ground rock is mixed with sulphuric acid in reaction tanks, a suitable proportion of the recycled fine product is added and the mass kneaded in a paddle mixer. The mixture is dried and screened. Phosphoric acid is manufactured by the interaction of sulphuric acid and ground rock, larger amounts proportionately of the former being used than in the manufacture of single superphosphate and the reaction carried to a further stage. The insoluble calcium sulphate and rock residue are removed by filtration and the acid in the filtrate is concentrated by evaporation.

Class (d) : Ground Rock Phosphate

43. Ground rock phosphate is manufactured simply by grinding rock phosphate to a degree of fineness sufficient to enable 80 per cent. of the product to pass through a British Standards No. 100 sieve. The degree of fineness is higher than that required for preparing rock for superphosphate production but the grinding is carried out in similar types of mills. The rock used is normally Gafsa rock, containing 65 to 68 per cent. tricalcium phosphate.

Class (e) : Basic Slag

44. Basic slag is a by-product of the manufacture of steel by the " basic " processes, whether Bessemer or open-hearth, in which pig iron is heated with lime, or lime and magnesia, to remove the unwanted phosphorus and silicon. In the basic Bessemer process the high temperature is obtained mainly by the combustion of these substances and pig iron containing phosphorus must accordingly be used. Until recently this process has only been workable with irons with a high P_2O_5 content whereas the open-hearth process can be used with the full range. The Bessemer process has consequently been associated with higher grades of slag than the open-hearth process. In this country the divergence has become less marked as a result of an increasing tendency to use similar irons for both processes. The degree of citric solubility depends on the presence of other materials. The addition of fluorspar, which is sometimes used as a flux, considerably decreases it. The basic Bessemer process was abandoned in the United Kingdom from 1926 to 1934 and today less than 5 per cent. of British steel is made by that process. On the Continent (France, Belgium, Luxemburg, West Germany) about 60 per cent. of steel is of Bessemer origin and, owing in part it seems to the addition of mineral phosphate to the converters, the slag is generally of higher P_2O_5 content, though not of soluble P_2O_5 content, than the highest grade now produced in the United Kingdom. For fertiliser use basic slag is ground to a fineness sufficient to allow 80 per cent. of it to pass a British Standards No. 100 sieve.

Class (f) : Compounds

45. *Inorganic compound fertilisers* are for the most part made by the thorough mixing of straight fertilisers, finely powdered, in predetermined proportions. Granulation, if required, is effected by the addition of water or steam to the powder mixture, followed by drying, cooling and screening.

The typical ingredients are ammonium sulphate, single (and for high analysis compounds, triple) superphosphate and muriate of potash. Finely ground phosphate rock is used as an ingredient in potassic mineral phosphate (P.M.P.) and in a few other compounds.

46. A number of important compound fertilisers including most of the more concentrated are made by other processes. These include C.C.F. made by I.C.I. and some similar compounds made more recently by S.A.I.; Kaynitro* made by I.C.I.; and certain new compounds made by Fisons. *C.C.F.* In the process used by I.C.I. phosphate rock is ground and reacted with sulphuric acid and ammonium sulphate solution to yield a mixture of phosphoric acid and solid calcium sulphate. The latter is removed by filtration and ammonia gas is added to the filtrate, yielding monammonium phosphate. Some of the water is removed by evaporation and the solution is then mixed with potassium chloride and solid ammonium sulphate. The mixture is fed into a rotating cylinder where it is dried. The granules formed are screened for uniform size. *S.A.I.* produces four concentrated compounds based on ammonium phosphate. The process used, though it differs in some respects, is broadly similar to that used by I.C.I. *Kaynitro.* For this production ammonium nitrate solution is concentrated by steam heat under vacuum and then mixed with the main ingredients, solid ammonium sulphate and solid potassium chloride. The product is granulated and screened. Certain of *Fisons'* new compounds are also made from concentrated ammonium nitrate solution.

47. *Organic-inorganic compounds* are made by mixing two or more of a wide range of constituents including, on the inorganic side, potash, ammonium sulphate and superphosphate and, on the organic side, fish meal, bone meal, horns and hooves, dried blood, hop waste and sewage sludge. The product may be "pelletted", giving it a quasi-granulated form.

CHAPTER 2. THE HISTORY AND ORGANISATION OF THE CHEMICAL FERTILISER INDUSTRY

I. History

48. The use of chemical fertilisers to increase the productiveness of the soil dates from the early years of the nineteenth century. Despite this development, the ancient practices of using manure of animal origin (dung, bones, blood, wool waste) or of "green manuring"—i.e. the growing and ploughing in of "catch", or sometimes main, crops—have persisted as well. For many years after the development of chemical fertilisers Peruvian guano was imported in large quantities, and today farmyard manure and to a lesser extent other organic fertilisers still make an important contribution to soil nutrients in this country.

49. The first chemical fertiliser to be developed was *calcium superphosphate.* Early in the nineteenth century it was discovered that the phosphate present in bones could be made more readily available to the plant if the bones were dissolved in sulphuric acid. Shortly afterwards it was

* "KAYNITRO" is a registered trade mark.